Geographical Review

July 2005
Volume 95, Number 3

New Geographies of the Middle East

THE GEOGRAPHICAL REVIEW

VOL. 95, NO. 3 JULY 2005

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The Geographical Review 95 (3): 301–488, July 2005

OPERATION IRAQI FREEDOM: A MILITARY GEOGRAPHICAL PERSPECTIVE*

EUGENE J. PALKA, FRANCIS A. GALGANO, and MARK W. CORSON

ABSTRACT. The war in Iraq has spanned the full spectrum of military operations: intense combat, stability-and-support operations, and peacetime activities. Regardless of their nature and relative intensity, military operations are shaped by the characteristics of the military operating environment. Consequently, the scale, tempo, and complexity of any type of military endeavor are linked to the physical and cultural landscapes of the region in which it is conducted. Military geographers use geographical information, tools, and techniques to examine those links. Iraq's operating environment is studied to identify the relevant components of its physical and human geography. This military geographical examination of Iraq tells us a great deal about how the physical and cultural environment have influenced the war, as well as how the complexity of its human landscape continues to affect the postwar rebuilding of the country.
Keywords: geotechnology, Iraq, military geography, Operation Iraqi Freedom.

Wartime military operations stem from and are governed by political decisions and are usually considered a last resort, to be employed only in defense of the country or after diplomatic, economic, informational, or lesser military options fail to achieve their desired effects. Military activities within the context of stability-and-support operations, however, are often humanitarian in nature, and, although they are generally well received even in the most hostile or austere places, they can be equally if not more complicated and volatile than conventional combat operations (Palka 1995, 2003, 2005). Stability-and-support operations include nation building, security assistance, disaster relief, providing support to counter drug operations, peacekeeping, arms control, combating terrorism, shows of force, noncombatant evacuation, and providing support to domestic civil authority (Palka 2005). Understanding the natural and human environment is a fundamental requirement for planning and conducting military activities, irrespective of their nature or where they occur (Palka and Galgano 2005). Military planners routinely strive to understand the physical and human geography of potential areas of operation, as well as to identify and incorporate the appropriate geographical tools to support and sustain their analysis throughout a campaign.

This article provides a geographical analysis of the Iraqi operating environment and of Operation Iraqi Freedom. We first briefly outline the deterioration of relations between the United States and Iraq that eventually led to the ongoing war. The analysis of Iraq's physical geography addresses its location, size, landforms, and rivers and considers the pervasive influence of weather and climate on combat opera-

* The authors are extremely grateful to the editors, Doug Johnson and Viola Haarmann, to the guest editor, Dona Stewart, and to the anonymous reviewers who provided constructive criticism, valuable insights, and recommendations to improve earlier versions of the article.

DR. PALKA is a professor of geography at the United States Military Academy, West Point, New York 10996, where DR. GALGANO is an associate professor of geography. DR. CORSON is an associate professor of geography at Northwest Missouri State University, Marysville, Missouri 64469.

The Geographical Review 95 (3): 373–399, July 2005

tions. The human geography is examined in terms of culture, ethnicity, and urban geography and their effects on military activities. The final aspect of the study focuses on geographical technologies—remote sensing, digital cartography, GIS, and GPS—and outlines their role during Operation Iraqi Freedom.

In some respects, traditional military geographical approaches are inadequate for acquiring complete understanding of Iraq's rapidly changing natural and cultural landscape (O'Sullivan 2001; Palka 2003; Woodward 2004; Black 2005; Mamadouh 2005). To contain the scope of the article, we have made a conscious decision to resist the temptation to address a plethora of important, interesting, and highly controversial topics that must be part of a more comprehensive military geography. Issues such as the search for weapons of mass destruction, the politics surrounding the United States' incursion into Iraq, the legitimate use of military force, the role of private military companies before, during, and after the war, and the geographical nature of the ongoing insurgency—to cite only a few examples—each warrant book-length coverage but are not the focus of this article. Our objective is to provide a basic military geographical analysis that enhances an understanding of Iraq's military operating environment.

Background to the Conflict

At the same time as Saddam Hussein seized power in Iraq in 1979, the shah of Iran was overthrown by a revolution led by fundamentalist militants who established an Islamic republic under the leadership of the Ayatollah Khomeini. Iraqi distrust of the Persian Iranians dates back thousands of years to the domination of Mesopotamia by Persian kings. Hussein also distrusted the Shia and the new Iranian theocratic regime and believed that an opportunity existed to settle both ancient wrongs and to reverse unilateral alterations in control of the Shatt al-Arab imposed by the shah when Iraq was relatively weak (Swearingen 1988). Because of the turmoil caused by the Iranian revolution, Hussein perceived Iran to be ineffectual and vulnerable. In September 1980, he launched what would be a disastrous war with Iran. Though initially successful, the conflict deteriorated into an eight-year-long stalemate. Before the two countries agreed to peace in 1988, close to 1 million Iraqis and Iranians had died, Iraq was nearly bankrupt, and no territory had changed hands (Tibi 1998). Ironically, the United States supported Iraq throughout the ordeal.

Having been frustrated in Iran, Hussein turned his attention to Kuwait, whose government had supported Iraq politically and financially throughout the war with Iran, and accused its regime of interfering with and stealing oil from Iraq's southern fields. He revived claims based on provincial boundaries in the Ottoman Empire to create a case that Kuwait actually constituted Iraq's historic nineteenth province (Ochsenwald and Fisher 2004). In August 1990 Iraq invaded Kuwait, initiating the first Gulf War. Iraqi forces secured the country in three days and subsequently announced its annexation to Iraq. Iraqi units then massed near the Saudi Arabian border, threatening Saudi oilfields and roughly one quarter of the world's proven oil reserves. The United States responded by organizing an international

coalition to protect Saudi Arabia in what came to be known as Operation Desert Shield. With United Nations support and a Security Council resolution calling for Iraq to disengage from Kuwait, the coalition launched Operation Desert Storm in February 1991. Following a six-week-long air campaign, an American-led ground force drove the Iraqis from Kuwait and seized southern Iraq in only 100 hours of ground combat. Not having a mandate to change the Iraqi regime, and having accomplished their mission of liberating Kuwait, the coalition forces withdrew from Iraq with their primary mission completed but with Hussein and his Ba'ath Party remaining in power (DOD 1992).

The Arab Ba'ath Party originated in 1945 as a secular, socialist, pan-Arab, nationalist political party. The word *ba'ath* means "revival" or "resurrection" and expresses the party's commitment to Arab unity, freedom from foreign domination, and the progressive development of the Arab people. The Ba'ath Party in Iraq first became prominent as a dominant supporter of a coup led by Col. Abd al-Salam Arief in 1963. A series of purges and coups consolidated Ba'ath influence on the government, which became complete when Ahmed Hasan al-Bakr became head of state in a bloodless coup in 1968. The Ba'ath Party remained in power until 2003, becoming heavily militarized after Saddam Hussein assumed control in 1979. Ba'ath retention of power within Iraq following defeat in the first Gulf War, and its leaders' determination to assert control over Iraqi national space, generated constant tensions with the United States and the United Nations and resulted in the retention of sanctions designed to produce compliance with international mandates.

For the next decade, Iraq suffered under U.N. sanctions that caused severe shortages of consumer goods, medicine, and food. To ease the burden on the Iraqi people, the United Nations initiated the Oil for Food Program, which was designed to permit Iraq to sell enough oil to buy food and medicine. The Iraqi government managed to divert nearly a third of the Oil for Food Program revenues to the rebuilding of its military forces. Hussein was also suspected of trying to reconstitute his chemical, biological, and nuclear weapons capabilities.

The 9/11 destruction of World Trade Center towers in New York and the attack on the Pentagon by al-Qa'ida terrorists were the hostile acts that initiated the global "war on terrorism." President George W. Bush identified three countries—Iraq, Iran, and North Korea—as the "Axis of Evil," and the stage was set for further conflict with Iraq. Throughout late 2002 and early 2003 the Bush administration made its case against Iraq and sought to build a U.N.-sanctioned coalition to use military force against a country that the U.S. government regarded as being ruled by a rogue regime. Although Russia, France, and Germany thwarted U.S. efforts to obtain U.N. sanction for military action against Iraq, President Bush launched Operation Iraqi Freedom (Murray and Scales 2003).

Operation Iraqi Freedom

On 21 March 2003, Secretary of Defense Donald Rumsfeld and the chairman of the Joint Chiefs of Staff, Gen. Richard Myers, held a press conference to articulate the

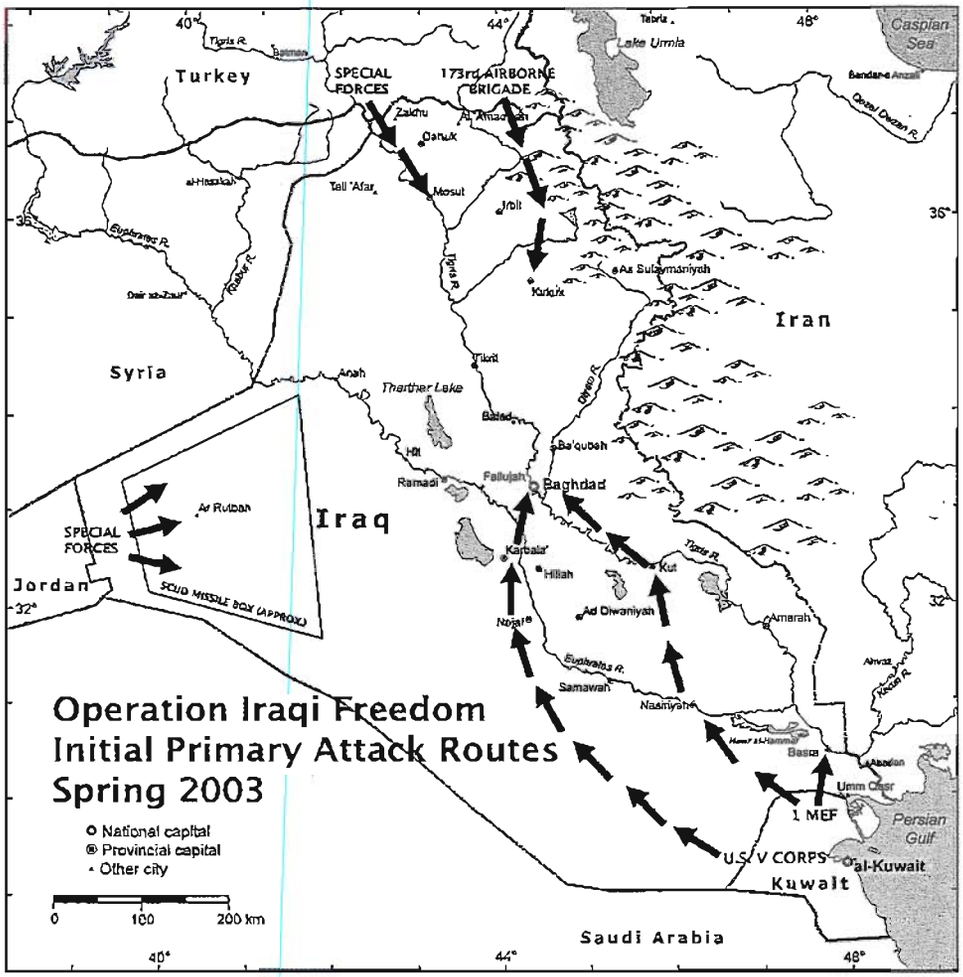

FIG. 1—Primary attack routes used by coalition forces in the initial stages of Operation Iraqi Freedom in spring 2003. (Cartography by the authors)

objectives of Operation Iraqi Freedom. Their stated objectives included ending the Ba'ath party regime of Saddam Hussein, identifying, isolating, and eliminating Iraq's weapons of mass destruction, capturing and driving out terrorists who had found a safe haven in Iraq, collecting intelligence related to terrorist networks in Iraq and beyond, ending sanctions and delivering humanitarian relief to Iraqi citizens, securing Iraq's oil fields and resources for Iraqis, and helping the Iraqi people create the conditions necessary for a rapid transition to representative self-government (DOD 2003).

The United States and its major ally, the United Kingdom, had experience with deploying forces to Iraq. In 1990 the U.S.-led coalition had massed nearly 500,000 troops in Saudi Arabia. But in 2003 the political situation had changed, and Saudi Arabia was unwilling to offer its territory as a staging base. Kuwait became the key

staging area, and the United States established major transportation operations at the country's one major seaport and its single international airport. Kuwait's seaport, airport, and excellent highways proved capable of handling the influx of troops. The northern portion of the country, primarily empty desert, became home to a number of camps that supported the buildup (Murray and Scales 2003).

The U.S.-led coalition included troops from thirty-one counties. With the notable exception of the United Kingdom and Australia, which provided substantial forces, most of these were small, though politically important, contingents. The main U.S. forces were the U.S. Army V Corps and the First Marine Expeditionary Force (1 MEF).

The V Corps had the equivalent of three divisions (about 75,000 soldiers) and launched its attack from Kuwait northward toward Baghdad, remaining west of the Euphrates River (Figure 1). By choosing this route, the V Corps bypassed most of the populated areas and moved rapidly through the desert. Simultaneously, the 1 MEF, which included the British First Armored Division as well as the U.S. First Marine Division (about 35,000 troops), attacked from Kuwait through the heartland of Iraq. Eventually the U.S. 3rd Infantry Division would attack Baghdad from the west while the 1 MEF attacked Baghdad from the east (Williamson and Scales 2003). The U.S. 3rd Infantry Division is home based at Fort Stewart, Georgia, near Savannah, and is normally a component of the U.S. XVIII Airborne Corps. But for Operation Iraqi Freedom this division was assigned to the U.S. V Corps. A division is a combined arms organization—containing infantry, armor, artillery, engineer, and other formations—of about 16,000 soldiers and is the smallest tactical unit in the U.S. Army capable of sustained, independent action on a battlefield. Divisions are typically assigned to a corps headquarters to accomplish specific missions. The British First Armored Division secured southern Iraq by seizing the port cities of Basra and Umm Qasr, thus protecting the flank of the Americans (UKMOD 2003a).

Coalition special operations forces entered Iraq from Jordan to eliminate the SCUD missile threat against Israel. The U.S. 4th Infantry Division, which is home based at Fort Hood, Texas, north of Austin, had planned to operate independently from, but in conjunction with, the U.S. V Corps attack under the control of the Joint Coalition headquarters. Even though the Turkish government refused to allow the 4th Infantry Division to attack Iraq from its soil, it did permit the coalition to deploy Special Forces into northern Iraq. Special Forces troops linked up with Kurdish militia, and, supported by the airdropped U.S. 173rd Airborne Brigade, secured northern Iraq and occupied substantial numbers of Iraqi forces. The 173rd Airborne Brigade—about 3,500 soldiers—is home based in Vicenza, Italy. The brigade made a parachute assault into the area around Kirkuk and operated independently from, but in conjunction with, the U.S. V Corps attack under the control of the Joint Coalition headquarters.

On 1 May 2003, speaking aboard the USS *Abraham Lincoln*, President Bush declared that major combat operations in Iraq had ended. He also stated that the coalition was engaged in securing and reconstructing Iraq. Most listeners fully ab-

sorbed the first part of the statement, but few recognized the imbedded challenges of the latter part. Expectations that the mission was complete and the coalition could redeploy the troops, as it had in the first Gulf War, were widespread. To military planners and leaders, the president's message simply reiterated that the combat operations phase of Operation Iraqi Freedom had come to an end and that the transition to stability-and-support operations was about to begin. No one expected the transition between these two phases of the campaign plan to be easy or irreversible: Iraq had no functioning government, its infrastructure was badly damaged, stability was threatened by terrorist groups from outside the country, and no Iraqi consensus existed on a vision for the country's future. In October 2003 the United Nations authorized the occupation while calling for an early transfer of sovereignty to the Iraqis. A massive rebuilding effort began to repair the damage from the war, the damage caused to political institutions by thirty years of authoritarian Ba'ath party rule, and the postwar looting of the country by Iraqis.

By June 2003 a growing insurgency was evident, as groups with varying agendas found common cause in challenging the coalition occupation (Clark 2004). Within the "Sunni Triangle" in the center of the country, a combination of Ba'ath party supporters, Iraqi nationalists, and foreign terrorists launched bloody attacks targeting U.S. logistics convoys. The insurgents proved to be resourceful and adaptable and began using the massive amounts of leftover munitions from the Hussein era to create improvised explosive devices, which they planted as remotely detonated roadside bombs (Fontenot, Degan, and Tohn 2005). In Shia areas to the south, a radical Islamic cleric, Moqtada Sadr, launched an insurgency to expel the coalition and put himself in a position of power. The opportunity to combat the Americans attracted foreign fighters, and a virtual underground railroad of *jihadists* developed, bringing mujahideen from all over the region. Many of these fighters joined the ranks of the Jordanian militant and al-Qa'ida commander Abu Mussab al-Zarqawi.

The coalition reacted to the insurgency with military force and political maneuvering. By mid-2004, Iraqi security forces were slowly being rebuilt. An Iraqi interim government under Prime Minister Iyad Allawi was installed in June 2004, and plans were made for the nationwide election of a new government on 30 January 2005. In the meantime, Sunni insurgents and foreign terrorists launched a campaign of intimidation and murder to derail the election and destroy the emerging Iraqi civil society, creating a pattern of chaos, intimidation, and insecurity that continues to the present and contains the seeds of potential civil war among rival religious, ethnic, and political communities.

Iraq's Military Operating Environment

The link between geography and warfare is clear. Places matter, and each place is unique; each possesses a discrete set of geographical imperatives that affect military operations. Furthermore, places interact, thus creating compelling and sometimes difficult dynamics and conditions within which military units must function. Aspects of geography such as weather, climate, topography, and cultural landscapes

have had a profound and sometimes decisive influence on military operations throughout history (Winters and others 1998). Important geographical concepts such as location, time, space, and distance must also be considered during the planning and execution of any military operation (Stephenson 2003).

Military geographers typically think of places as operating environments, each exclusively influenced by the interrelationship of a distinct set of geographical variables. The military operating environment is the sum total of all factors of the physical and cultural landscape that shape and control the ebb and flow of a military operation. In his 1832 treatise Karl von Clausewitz called the military operating environment "terrain," "the territory and inhabitants of the whole theater of war" ([1832] 1982, 292). Furthermore, von Clausewitz demonstrated that the operational significance of the operating environment varies with the mission, organization and type of military units involved, technology, and current circumstances. The geographical assessment of the military operating environment varies accordingly, based on what the environment is like, and why, and how this environment will influence the military operation.

Clausewitz's lesson is as true today and as it was then, and it has certainly manifested itself during operations in Iraq since the beginning of hostilities in March 2003. The nature of military activity has changed over time, from large-unit combat operations to counterinsurgency tactics, thus requiring adjustments in the assessment of the operating environment. Events in Iraq have suggested that the geographical assessment has perhaps not kept pace with the shifting mission and threat.

In a wartime geographical context, military planners typically think of the operating environment in terms of distinctive planning considerations. Various authors have suggested frameworks for analyses (see, for example, Peltier and Pearcy 1966; O'Sullivan 1991; Collins 2003; Palka 2003). In the final analysis, however, an examination of the military operating environment typically results in an assessment of some combination of such factors as key terrain features (strategic areas and selected critical targets and objectives), surface structure (movement corridors and terrain compartments), critical topographic variables (relief, hydrological features, and landforms), transportation networks (road and rail systems, ports and airfields), resources (host-nation support, clean water, and medical facilities), logistical requirements (food, medical supplies and infrastructure, specialized equipment, ammunition), observation and concealment (ground and air), and human landscape elements (population, ethnic groups, and urban features, among others).

THE CHALLENGE OF LOCATION

To understand the military geography of the Iraq conflict, the location of the country offers important insights into the region's accessibility and physical dynamics, such as climate and weather patterns, medical issues of health and disease, and the physical stresses imposed on human activities (Thompson 2004). These attributes form essential baseline information in terms of the size and training requirements of the military force, especially because so many National Guard soldiers and civil-

the United States. Iraq's geographical center lies at about 33° N, 44° E, about the same latitude as the state of Tennessee. Iraq is remote from the United States: about 9,538 kilometers from the East Coast and 11,000 kilometers from the West Coast by air. Thus, a nonstop aerial deployment from the United States takes more than twelve hours with aerial refueling en route.

Distance and location are problematic in terms of a maritime deployment as well. From the East Coast, cargo and naval craft must cross the Atlantic Ocean and then transit one or more of the world's critical choke points. Using the northern route from the U.S. East Coast, ships must negotiate the Strait of Gibraltar, the Strait of Sicily, the Suez Canal, the Bab al-Mandeb at the southern exit from the Red Sea, and the Strait of Hormuz. The southern route from the East Coast, which is twice as long, requires ships to navigate past the Cape of Good Hope, transit the Mozambique Channel between continental Africa and Madagascar, and negotiate the Strait of Hormuz to enter the Persian Gulf (Peele 1997). From the U.S. West Coast, ships must transit the congested Strait of Malacca between the Malay Peninsula and Indonesia, followed by passage across the western Indian Ocean and through the Strait of Hormuz. These deployments are time consuming and expensive, requiring approximately twenty-three days from the East Coast and fourteen days from the West Coast (Corson 2000).

IRAQ'S PHYSICAL REGIONS

Physical geography is the template upon which military operations must take place. Weather, climate, vegetation, soils, and terrain are essential factors in planning military operations. Various types of operations also can be shaped in fundamentally different ways by the same operating environment. Although most people think of Iraq as a vast, subtropical desert, the country has diverse climates and physical landscapes. The war, and now the counterinsurgency, is being fought over various physical landscapes spanning Iraq's two seasons and several climate regions in an area roughly the size of California, a setting that provides numerous challenges to military operations. Iraq's three major geographical regions, centered around the Tigris and Euphrates basin, are depicted in Figure 2 (Collins 2003). The Tigris and Euphrates Rivers and their major tributaries originate in the uplands of southeastern Turkey and northwestern Iran and flow through the center of Iraq, carrying silt from which the region's rich alluvial soils are constructed as well as water for agriculture. This river basin includes nearly 75 percent of Iraq's population and infrastructure (Nyrop and Smith 1979).

Region I consists of a flat, barren desert plain that extends from the Persian Gulf and northern Saudi Arabia beyond the western borders of Iraq and deep into Jordan and Syria. This great expanse of desert is nearly featureless to outsiders, although nomadic herders who visit the area in the winter and the very scattered resident population are able to navigate it successfully. Despite its superficial homogeneity, the region has a microtopography that includes many wadis and a few

FIG. 2—Iraq's principal physical regions. Region I encompasses the subtropical desert; Region II, the alluvial basin of the Tigris and Euphrates Rivers; Region III, the highlands. *Source:* Adapted from Collins 2003, 3. (Cartography by the authors)

small escarpments, which are important features in terms of maneuvering and concealing military units (Nyrop and Smith 1979). The climate is hot and dry, with extremely low annual rainfall totals of less than 100 millimeters and daily average temperatures that typically range from 32°C to 38°C. Because of the pervasive aridity in the desert, little permanent vegetation can survive (Nyrop and Smith 1979; Collins 2003). Exceptions to these conditions occur where groundwater exists close to the surface or when surface runoff collects following winter storms and supports the growth of annual grasses.

Region II is Iraq's central alluvial basin, which correlates with the region of ancient Mesopotamia (Collins 2003; Corson 2005). The region is bounded on the east by the Tigris River and on the west by the Euphrates, which form a common delta

FIG. 3—Iraq's climatic regions. *Source*: Adapted from Pannell 2004, 17. (Cartography by the authors)

near Basra, create an immense marsh, the Hawr al-Hammar, as well as adjacent smaller swampy districts, and then meander southward to the Persian Gulf in a combined channel, the Shatt al-Arab. The region includes numerous swamps, mudflats, lakes, canals, ditches, and dikes. The rivers, their extremely flat and poorly drained floodplain, and their marshy lower course present obstacles through which it is difficult to maneuver (U.S. Army 1992).

Region III is Iraq's northern, mountainous area where elevations increase from south to north, from the uplands near Kirkuk and Irbil to the mountains along the Turkish and Iranian borders. Here mountain peaks rise up to 3,600 meters above sea level. This area's geology produces the region's numerous earthquakes, and some of Iraq's most important petroleum deposits are found in the foothills around Kirkuk (Sampson 2004).

THE CHALLENGE OF CLIMATE

Iraq's climate is characterized by hot, dry summers and mild winters with little precipitation, although some local variations from this pattern do occur. Summer (June-September) and winter (November-April) constitute the two major seasons, separated by month-long transition periods. Within this seasonal pattern, three climate zones are distinguished: subtropical desert, subtropical steppe, and Mediterranean (Figure 3). Iraq is strongly influenced, particularly in summer, by subtropical high pressure, which generates clear skies and very dry air throughout the year.

The southwestern region has a subtropical desert climate with extremely high summer temperatures, which occasionally reach daily highs of 54°C, and mild daytime temperatures in the winter. The region extending northward from Baghdad to Kirkuk, with its subtropical steppe or grassland climate, has cooler temperatures and receives slightly more winter rainfall than do the desert areas of the southwest. Winter precipitation results from the sporadic passage of cold fronts associated with periodic extratropical cyclones that cross the Mediterranean and pass through the region during late winter and early spring. The higher elevations of northern Iraq are much wetter and cooler than the countryside south of Baghdad. Orographic lifting generates increased rainfall in the region, and the sporadic passage of winter frontal activity introduces more precipitation. The mountains become very cold in the winter, and snow is common at altitudes above 1,300 meters. The climate and weather of Iraq generate three major natural hazards: drought, flooding, and sandstorms. Flooding and sandstorms had significant impacts during the early stages of Operation Iraqi Freedom, hindering ground maneuverability, air mobility, and tactical air support and posing a risk to the health and safety of troops engaged in active combat.

PHYSICAL GEOGRAPHY AND MILITARY OPERATIONS

Physical geography has and continues to have a major influence on military operations in Iraq. Iraq's relatively large size causes military units to maneuver over long distances, with equally long and vulnerable supply lines. During the invasion, the main supply route from the Kuwaiti border to Baghdad covered a distance of 525 kilometers. A convoy of supply trucks required five days to make the complete circuit between Baghdad and Kuwait. The long, exposed supply lines posed a major problem for U.S. forces because Iraqi insurgents found them to be particularly lucrative targets. In hindsight, the U.S. invasion plan did not provide for adequate security along these vulnerable supply arteries (Fontenot, Degan, and Tohn 2005).

Much of central, southern, and western Iraq is a flat, featureless desert, hot, dry, and dusty for much of the year, with little permanent vegetation outside the areas that are irrigated and the swamps that are nourished by the seasonal flooding of the Tigris and Euphrates Rivers. This dryland habitat poses four fundamental challenges to military operations: navigation and concealment issues, pervasive dust, the effect on humans of temperature and aridity, and the impact of fluvial features.

In many ways the seemingly featureless desert is the most challenging problem in Iraq. Navigation in a region without readily identifiable landmarks is inherently difficult, a handicap that is not shared by local forces who have access to people with intimate, lived-in familiarity with the local environment. In practice this generally proved to be a problem that U.S. forces could overcome by using GPS. Despite the widespread use and significant advantage of GPS technology, however, troops often had to resort to conventional methods of land navigation, which depend on map reading, use of a compass, and terrain association. Far more serious for contemporary military operations is the fact that the apparently featureless nature of the Iraqi desert can be deceptive. Although the near absence of vegetation and seemingly flat terrain permits extended visibility, the region exhibits a great deal of "microterrain." The microterrain, which includes wadis and dunes that create "intervisibility lines" in the landscape, is of little value in terms of concealing large, modern forces. But small, fast-moving insurgent forces can find adequate concealment throughout the region (Hoffman 2004). Intervisibility lines are small, almost imperceptible undulations on the desert floor that can effectively conceal small forces and individual vehicles from being observed by other units at ground level.

The microterrain, combined with the expansive spaces of the desert, has enhanced insurgent operations, especially in western Iraq. American forces, initially configured and equipped to detect and fight large, mechanized forces in the open desert, were compelled to reorganize and adopt new methods for employing available technology to defeat this unforeseen enemy advantage (Hoffman 2004). Aerial surveillance platforms, the use of unmanned aerial vehicles, and electronic signature-detection systems are examples of readily available technology designed to enhance intelligence gathering and target detection in such austere places. Insurgents in western al-Anbar Province, however, continue to use the remote nature of the terrain to infiltrate into urban and periurban areas of Iraq (Hoffman 2004).

The poorly developed, dry soils in the Iraqi desert are inherently dusty. This is especially problematic for a mechanized force because dust is highly damaging to engines, necessitating specialized air filters and more frequent maintenance stops during operations. Iraq's desert soils are unique in that they contain abundant amounts of carbonates, sulfates, and chlorides, along with silt- and clay-sized particles. This type of dust, when mixed with various lubricants, promotes the formation of sand-sized aggregates and proved to be particularly damaging to rifles, machine guns, and helicopters (McDonald and Caldwell 2005). Soldiers were required to maintain their weapons in ways far different from those mandated for more temperate environments, and helicopters needed specialized rotor blades in order to operate safely in an environment with highly abrasive dust. Pervasive dust is a fact of daily life in the Iraqi desert. The surface material in southern Iraq is fine clay with the consistency of talcum powder. This "sand" gets into everything and had an adverse impact on troop morale, air and ground operations, and equipment operability. The impact of the dust on equipment ranged from bothersome to life threatening. Because of the experience in the first Gulf War, most U.S. equipment

was fairly resistant to the dust, but its performance was degraded. Despite improvements to engine air-filter systems, the pervasive, fine dust continued to degrade airflow, causing motors to run at higher temperatures, thus accelerating wear on components and degrading fuel efficiency. Additionally, blowing desert particles are angular by nature and abrasive. The blowing clasts caused scratches in optics, reducing their efficiency regardless of protective measures. Finally, dusty conditions can interfere with lasers, degrading guided munitions and range finders.

British forces discovered during training exercises in Oman in 2001 that their main battle tanks worked fine in Europe but performed dismally in the desert. Air filters clogged, and the engines lost power or overheated. Retrofitted tanks with improved filters reduced the dust problem and kept more than 90 percent of British tanks operational throughout the war (UKMOD 2003b). Aircraft and helicopters were also adversely affected by the dust. Aircraft simply could not fly in the turbulent dust storms, and helicopters were susceptible to greater blade wear than normal from the abrasive effect of the dust.

Operation Iraqi Freedom was launched just prior to the transition from winter to summer, when temperatures begin to warm. Operations continued into the summer period, and by August the temperature made even simple, day-to-day activities difficult. Because of the perceived threat of chemical weapons, coalition soldiers initially wore heavy chemical protective suits. Those suits hindered movement and made heat-related illnesses and injuries a constant threat. Wearing heavy chemical suits in the hot, dry environment was a daily challenge. The suits cause soldiers to nearly double their water intake; however, the nature of the protective gear makes drinking very difficult. Thus soldiers are frequently susceptible to heat exhaustion and can also suffer from dizziness and restricted vision (from the mask), which can cause vertigo or disorientation. These conditions are not life threatening, but they do lower efficiency and slow routine operations considerably. Gradual acclimatization to the conditions and sufficient levels of hydration were extremely important in long-term mitigation of these heat-related impacts (Fontenot, Degan, and Tohn 2005).

Aridity and high temperatures are fundamental planning considerations for a military force operating in a desert environment. The most obvious combined influence of aridity and heat is their impact on soldiers, particularly those recently arrived from temperate environments. The accepted acclimatization period for the summer period (April-October) is about three weeks (Gamez and Watson 2004). The need for an ample supply of clean drinking water is self-evident. The less obvious effects of aridity and heat are their physiological effects on soldiers. Human tolerance for climatic variation is actually quite limited. Temperature variations of more than 5° above or below 21°C will generate discomfort and impair performance. A 9°C increase in temperature above 21°C will cause the average body to respire more rapidly, and an 18°C increase will establish conditions for heat exhaustion and, potentially, heatstroke.

In Iraq these physiological circumstances are exacerbated by the extreme aridity, which causes soldiers to dehydrate more quickly. Other physiological condi-

tions attendant to this hot, dry, and dusty climate include eye infections, severe chapping of the lips and skin, sun blindness, and a host of other problems. Individually, these afflictions are generally considered minor, but for soldiers operating in austere environments their combined effects can be debilitating. Experience has shown that individual performance tails off considerably after the first seventy-two hours in the desert environment. This has been especially true for National Guard and civilian contractor organizations deployed to Iraq.

Provision of water was a major challenge, for each soldier needed several gallons of drinking water each day. The U.S. Army has water-purification units that can withdraw polluted river water and render it drinkable, but distributing the potable water was a problem. As a result, the troops had to drink bottled water, which put a burden on the logistics system.

For a desert war, fluvial features played a surprisingly critical role. Because coalition forces feared that the Iraqis would demolish bridges to slow their advance and increase their vulnerability, the Americans practiced river-crossing operations before the outbreak of fighting and brought with them a tremendous amount of bridging equipment. But initial planning for the 2003 attack into Iraq established that the V Corps would be required to conduct nearly 800 individual water-crossing operations, an effort that would have required more bridging equipment than was available in the army inventory. This geographical analysis led to alteration of the plan, and the V Corps made its now-famous drive across the desert, east of Samawah and Najaf to the Hillah gap (see Figure 1).

Another unforeseen aspect of the fluvial landscape in both the desert and the river-basin environments was flooding. American forces did not initially take drainage into account when they built their base camps in Iraq and Kuwait. Consequently, with the onset of the rainy season, most of the base camps were flooded: Tents were washed away, vehicle parking lots, maintenance facilities, and storage areas were flooded, and the water flowed between the protective berms of packed soil that had been constructed to enhance security and survivability, creating flash floods that undermined guard towers and other structures. A substantial engineering effort was needed to repair the damage and install a drainage system in each camp.

Iraq's Human Environment

The second major component of an operating environment is its cultural landscape. When they examine the human components of the operating environment, military planners try to assemble an integrated snapshot of the human landscape. The result is an appraisal of the region's population, culture groups, cultural institutions, settlement patterns, land use, economies, transportation and communication networks, and military capabilities. Iraq's physical landscape presented many challenges to military operations, but human activities often complicated matters even more. The geographies of culture, politics, urban areas, and infrastructure have significantly influenced the course of Operation Iraqi Freedom and continue to present challenges (Collins 2003; Corson 2005).

IRAQ'S CULTURAL DIVERSITY

Culture and ethnicity play a key role in understanding what has happened during Operation Iraqi Freedom. Iraq is a culturally fragmented country with three major ethnic/religious groups that share a long history of conflict and whose differing perspectives and objectives continue to shape the nation's political geography (Figure 4). Although most Iraqis are Muslim, they are fragmented along both religious and ethnic lines of cleavage. The three main groups are Shia Arabs, Sunni Arabs, and Sunni Kurds. In addition, a minority of Turkomans and other ethnic groups are clustered in and around Kirkuk.

Shia constitute the majority of Iraqis, accounting for possibly as much as 60 percent of the population, and are concentrated in the south and east of the country, from Baghdad to the Persian Gulf. Iran, to the east, is a Shia theocracy and has close cultural and religious ties with some elements of the Iraqi Shia leadership. Shiites, a distinct minority within the global Muslim community, were brutally suppressed by the Iraqi Sunni population for most of their history, and Saddam Hussein, a Sunni from Tikrit, continued this oppression. Historically, the Shia lived in the rural countryside or in smaller, peripheral cities. Basra, in southern Iraq, is a major Shia city, and the cities of Karbala and Najaf house many of their most important religious sites. Shiites differ from Sunni Muslims primarily in their understanding of how leadership should be identified in the Muslim community. For them, authority is hereditary and is linked to the Prophet Muhammad through his daughter Fatima and her husband, Ali (Esposito 2002). The Shia have their own form of hajj, which draws tens of thousands of pilgrims to Najaf, believed to be the final resting place of Ali, and Karbala, where Husayn, a son of Ali and Fatima, is buried. Hussein forbade the Shia to conduct this pilgrimage for three decades, a tradition that has resumed since his downfall in 2003. Shia clerics play an important role in directing their society, including the moral authority to encourage their followers to resist unlawful or unjust governments or to cooperate with existing governments and participate in elections.

Sunni Arabs are a minority, accounting for only about 20 percent of Iraq's population, but historically they were its ruling element. When the British occupied Iraq after World War I, they installed a Sunni monarch, the representative of a branch of the Hashimite family that had long dominated Mecca but had been driven out by Ibn Saud. It was the Sunni Arabs, living in the center of the country within the capital of Baghdad, who supported the new monarchy and continued to dominate the country's political and economic life. Hussein, and the Ba'ath party he dominated, maintained Sunni Arab control of Iraqi politics, feared both the Shia Arabs and the Kurds as divisive elements, and kept extremely tight control over both groups.

The Kurds are predominantly Sunni Muslims, but they are culturally different from the Arabs. The Kurds speak an Indo-European language quite unrelated to Arabic. Many Kurds live outside Iraq, in adjacent parts of Syria, Turkey, and Iran, but overall Kurdish unity is hindered because those groups often speak different dialects and have been shaped by different experiences. The Kurds are a classic "state-

less nation," a culturally distinct group that self-identifies as a nation but has no political state of its own. Many Kurds would like to create a state of Kurdistan from territory that includes parts of Iraq, Iran, Turkey, and Syria. This desire has bred insurgency at various times in each country where Kurds reside. Wider Kurdish unity has always been frustrated by internal differences, but this has not prevented Iraqi Kurds from pressing for greater cultural and economic autonomy within Iraq. In part because oil-rich Kirkuk is the main city of the Kurdish north, successive Iraqi governments have resisted giving meaningful autonomy to the Kurds and have been hostile to Kurdish independence activities in the wider region. Hussein suppressed the Kurds for decades, killed thousands of them with chemical weapons during the Iran-Iraq war, and moved substantial numbers of them from the north to the extreme south of Iraq. The Kurds have a reputation for being warlike, and a traditional hostility exists between the Kurds and the lowland Iraqi Sunni Arabs to the south (Malinowski 2004). Intra-Kurdish rivalries and tensions have also persisted for decades, especially during brief periods of relative tranquility, dispelling the notion of a unified Kurdistan.

Iraqi society is a juxtaposition of the old and the new. At the national level it has a secular government and a modern structure of administrative districts and regional governors. At the local level, however, a very important tribal system influences daily activities. Most Iraqis have a home village and tribe. Tribal sheiks wield great influence in local affairs, and tribal membership plays a major role in determining political power. Any effort to reform Iraq must take into account both the policy of the official national government and the viewpoints of the unofficial tribal and religious authorities.

THE POSTINVASION POLITICAL SCENE

Operation Iraqi Freedom had major political geographical impacts at multiple scales, both within Iraq and internationally. Several U.S. allies, including France and Germany, as well as Russia and China, did not support U.S. military action in Iraq. The Bush administration's "Coalition of the Willing" consisted mostly of small states providing small military forces, and some observers saw this coalition as little more than political cover. American credibility was dealt a major blow when coalition forces did not find weapons of mass destruction. On the other hand, European, particularly French and Russian, motivations for opposing the war were questioned by Americans when postwar investigations revealed that Hussein had made deals with key French, Russian, United Nations, and other officials and firms to sell them oil at below-market prices. Those investigations have led to the indictment of several U.N. officials and European diplomats, thus shedding new light on their reluctance to enforce existing U.N. resolutions. The result internationally was damaging to relationships among key North Atlantic Treaty Organization (NATO) allies and placed a strain on relations between the United States and Russia at a time when cooperation, intelligence sharing, and trust among partners was essential to combating international terrorism effectively.

FIG. 4—Iraq's major culture groups. *Source:* Adapted from Malinowski 2004, c-9. (Cartography by the authors)

The cultural geography of the Sunni and the Shia, as well as that of the Arabs and the Kurds, has a considerable influence on the political geography of Iraq. After World War I, Iraq was first a monarchy (1921–1958) and then a military dictatorship beset by numerous coups. Hussein assumed control of the government in 1979 and ruled for nearly twenty-five years through violence and intimidation, suppressing the political aspirations of both the Shia Arabs and the Kurds, as well as any Sunni Arabs who might have posed a challenge. Iraq has never known Western-style democracy. With Hussein deposed, Iraq was ruled by an occupation authority for a short time and then by an interim government. Iraq now stands on the eve of a new political era. A 275-member Transitional National Assembly was elected in January 2005, and a new constitution was ratified in October of that year. In December 2005

the Iraqi people elected a new government under this new, permanent constitution. Now various groups look toward the establishment of an effective government and await the long-term implications of the changes, some good, others unexpected and sometimes unwanted, unleashed by Operation Iraqi Freedom.

Most Iraqis are anxious to regain control of their country, accept responsibility for their own security, and see the coalition leave Iraq. Differences arise regarding how this is to be accomplished, and the vision for the country's future government and society generates considerable debate.

The majority Shia community had the most to gain from elections in which each adult has a vote. With a 60 percent majority, the election held in December 2005 was their grand opportunity to take political power after decades of repression. But the Shia are not unified: Rival religious leaders have made it difficult for the Shia Arabs to consolidate their power. The most powerful Shia cleric is the Grand Ayatollah Ali al-Sistani. He has proved to be relatively moderate in his view of the coalition occupation and called on his followers to participate in the December 2005 election. He regarded it as the best way for the Shia to take power and end the coalition presence. Ayatollah al-Sistani views himself as a religious figure and will hold no political office. His sanction of the election was essential for the Shia majority to participate and accept the outcome.

The other prominent Shia figure is the thirty-year-old cleric Moqtada Sadr, son of a popular Shia cleric who was killed by Hussein. Sadr City, named in honor of the cleric's father, is a major—and very poor—Shia neighborhood in Baghdad, with 2 million residents. Sadr has been a violent opponent of the coalition occupation and has instigated terrorist acts against coalition soldiers and Iraqi civilians who support the interim government. His appeal is to the masses of poorly educated, angry urban Shia youth, who have limited economic prospects. He launched a rebellion against the coalition in April and May 2004 in cities throughout central Iraq. His forces seized the Imam Ali Shrine—the most holy Shia religious site—in Najaf. After fierce fighting, which left many of his followers dead and central Najaf in ruins, Ayatollah al-Sistani intervened and convinced Sadr to stop his followers from fighting and to join the political process.

The Sunnis were very fragmented in their attitudes toward the December 2005 election. Many Sunnis suffered under the Ba'ath regime and were glad to see Hussein overthrown. Their primary fear was—and is—that they would lose their position of power, but many of them concluded that their best option was to participate in the electoral process and gain at least a share of power in order to protect their interests. Other Sunnis have a far different view: A major rebellion continues within the Sunni region of central Iraq, led by a diverse group of insurgents who fear that a democratically elected government will thwart their vision for the country. These insurgents wish to derail the political process by attacking coalition forces and all Iraqis who cooperate with the coalition and the interim government. These Sunni insurgents come from several backgrounds. Some are former Ba'athists who want to reestablish a Sunni-dominated Ba'ath secular government. Others are Iraqi nation-

alists who see the electoral process as a Western plot to dominate Iraq and control its oil. Still others are Sunni Muslim fundamentalists who regard the Shia as evil and want to establish a fundamentalist Islamic state akin to Taliban-ruled Afghanistan. These groups have been bolstered by foreign elements, possibly linked to Osama bin Laden. These foreign fighters, led by al-Zarqawi, have been responsible for many of the terrorist acts against Iraqi civilians, foreigners, and coalition forces.

The Kurds have enjoyed a degree of autonomy in northern Iraq ever since the end of the first Gulf War. Protected by their Peshmerga fighters and a coalition no-fly zone, Hussein was forced to let them run their own affairs. Peshmerga fighters are Kurdish armed forces that can be traced to the Kurdish independence movement in the early 1920s. More accurately described as a "militia," Peshmerga forces were allied with American troops during the early stages of Operation Iraqi Freedom and currently play a security role in northern Iraq. The Kurds currently support the coalition and have participated in the electoral process in order to ensure local control of the three northern provinces they dominate. The main Kurdish agenda is to ensure that a future Iraq is federal or decentralized in nature and that Kurds continue to enjoy substantial autonomy in local affairs. The Kurds are well organized and can call on a substantial number of fighting men. If their autonomy is threatened, or if the election of December 2005 fails to unify the country and civil war erupts, the Kurds will presumably fight for their independence. This would have major regional implications for the Kurds in Iran, Syria, and Turkey.

The future of Iraq has regional and international implications as well. The best-case scenario is that the national election of December 2005 succeeds in unifying the country and provides the stable leadership necessary to forge ahead. The Bush administration sees a stable and democratic Iraq as setting the example for the rest of the Arab world. The administration's hope is that other countries in the region will follow Iraq's path, undertake democratic reforms, and modernize their societies and economies, thus presumably removing the underlying causes of terrorism. Worst-case scenarios are that the results of the December 2005 national election are not deemed credible, do not produce a government strong enough to provide internal stability without abrogating the liberty of Iraqi citizens, or result in a radical Shia government unacceptable to either the Sunni Arabs or the Kurds. In the last scenario, a slow descent into the chaotic conditions conducive to civil war and the potential disintegration of the country into separate components is conceivable. Such instability could also adversely affect the world economy, prompting spikes in oil prices and possibly interrupting supplies.

A point often overlooked in the media is that the insurgency remains concentrated in a limited area of the country and has not spread significantly to the core areas of the Shia Arab south or the Sunni Kurdish north. Sadr's uprising in April-May 2004 raised the specter of a broad-based insurgency against the coalition. The coalition responded with both military force and adroit political maneuvering. Military forces attacked Sadr's insurgents in key areas, but with considerable sensitivity to the local ethnic and religious context. A serious problem was the cultural

sensitivity of Sadr-occupied sites such as the Imam Ali Shrine in Najaf. Had coalition forces significantly damaged this shrine, the result would have been an upwelling of Shia outrage comparable to the reprisals that followed the 23 February 2006 attack on the Askariya shrine in Samarra. The use of precision-targeted munitions and the judicious use of firepower enabled coalition forces to target the insurgents while minimizing civilian casualties and damage to cultural sites. In the Najaf confrontation, Iraqi security forces, backed by coalition troops, cleared sensitive cultural sites and interacted with the local populace, while assuming responsibility for military operations. A key element to limiting the insurgency was enlisting the aid of Ayatollah al-Sistani to intervene with Sadr and persuade him to cease fighting and join the political process. Although tremendous challenges persist, the coordinated but judicious use of military force, civil-military operations, and political maneuvering were all instrumental in limiting the scope of the insurgency and maintaining relative calm in the majority of the country.

URBAN GEOGRAPHY AND INFRASTRUCTURE

Of the 28.8 million Iraqis, 19.5 million, or 68 percent, live in urban areas (PRB 2005). Even the 9 million Iraqis in the rural countryside tend to live in nucleated settlements. This urbanized population has serious implications for military operations in Iraq, because fighting in cities becomes unavoidable. Iraq has a well-developed infrastructure of roads, airports, and a railroad in the central portion of the country, but elsewhere its infrastructure is poorly developed. Infrastructure has a major impact on military sustainment operations as well as on rebuilding efforts and the economic growth of the country.

Baghdad is a sprawling city on the Tigris River with a population of 5.6 million people. Home to a mix of Sunni and Shia Arabs, with numerous other minorities also well represented, it is the primate city and core of the country. Mosul, the second largest urban center, has 1.7 million inhabitants. Located in the north on the Tigris River, it is a largely Sunni city with a mixed population of Kurds and Arabs. Basra, Iraq's major seaport city, lies about 16 kilometers from the Persian Gulf. Its residents number 1.3 million, most of whom are Shia Arabs, and it is a major oil center (GlobalSecurity.org 2002).

Traditionally, military forces do not like to fight in cities, but the pervasive global trend toward urbanization and the fact that cities are key terrain features make it essential to bring them under control (Krulak 1999). During Operation Iraqi Freedom several key battles took place in urban settings. The seizure of Hussein's palaces in Baghdad in April 2003 broke the regime's resistance and precluded a long siege. The battle against Sadr's forces in Najaf, Karbala, and Sadr City forced him into the political arena, and the fight for Fallujah was a tactical victory that deprived the insurgents of a safe haven, albeit at considerable cost to the good will of the larger civilian population. Fallujah emerged as a center of Sunni resistance in late 2003. Throughout the early months of 2004 Ba'athist regime supporters, foreign terrorists, and other insurgent groups converged on this small city, making it a key

node of anticoalition resistance. Consequently, U.S. Marine units began an offensive in Fallujah during April 2004. After heavy fighting and inevitable civilian casualties, the U.S. Coalition Provisional Authority suspended operations on 17 April 2004, based on a cease-fire agreement with local leaders. However, by 30 October 2004, the cease-fire conditions collapsed, and insurgent activity rose to an unacceptable level. U.S. Marines, along with Iraqi units, entered the city and effectively cleared it as an insurgent base before the end of November.

A number of lessons were learned from these battles. A large force of well-trained troops is necessary for fighting to be effective in an urban environment. Distances are reduced, communication is difficult, and junior leaders with small groups of soldiers or marines must display initiative. Insurgents generally like to fight in cities, where, they believe, the advantage of a technologically superior adversary is negated. Precision firepower is essential to prevent excessive collateral damage, but to employ it in densely packed urban environments is to risk considerable unintended results. The use of precision-guided munitions from aircraft, as well as precision weapons such as guided antitank missiles, enables targeting of specific locations but cannot preclude the possibility of civilian casualties.

A historic rule of thumb was for tanks and armored vehicles to avoid fighting in cities, because they are vulnerable to ambush from the top and rear. During the battle for Baghdad in April 2003 , the 2nd Brigade of the U.S. 3rd Infantry Division launched an audacious armored thrust at high speed, straight into the center of the city, where they seized Hussein's palace. This attack broke the regime's resistance and demonstrated that armored forces could operate in urban terrain. A key factor was the nature of the modern Baghdad urban environment—relatively open and modern—and of the enemy—equipped with older equipment and mostly rifles and rocket-propelled grenades. In Najaf the marines incurred unacceptably heavy casualties despite their advanced urban combat training. The introduction into the fighting of Abrams tanks and Bradley fighting vehicles brought the armor-protected firepower needed to overcome the insurgents.

Urban environments range from the modern, open construction of central Baghdad to the narrow streets and densely packed buildings of older cities. Different areas of the same city have different types of buildings and different street patterns, depending on whether they are old or new, or commercial, residential, or industrial. Good intelligence and maps, as well as an understanding of layout and construction of the urban area, are essential knowledge for combat leaders in urban environments.

Often overlooked but of critical importance to successful military operations are supply, transportation, maintenance, and medical care. These logistics functions utilize the infrastructure of urban areas, roads and highways, railroads, airports, and seaports. Central Iraq had a limited, but well-constructed, road system that enabled the coalition to move rapidly to Baghdad. Highway 1, connecting Basra to Baghdad, was a six-lane superhighway that supported tactical and logistics traffic and served as the coalition's main supply route. Major towns were generally con-

nected by well-constructed, two-lane roads that facilitated military movement. The Iraqi Republican Railroad was spared coalition bombing, and its employees protected it from looters. By May 2003 the railroad had restored passenger and cargo service from Basra to Baghdad and thence to cities in the north and west. The coalition used the railroad to transport noncritical supplies such as bottled water, but the vulnerability of the single track was a concern. Ironically, despite the heroic efforts of the Iraqi railroaders to keep it working, insurgents eventually destroyed the tracks and the trains.

Saddam Hussein International Airport, on the west side of Baghdad, was seized as early as possible during the initial phase of combat operations. The airport had not functioned since 1991, when coalition forces cratered the runway and U.N. sanctions restricted air travel. The coalition used a long taxiway to reopen the airport to military transport aircraft and eventually repaired the runway. Civil air traffic resumed for the first time in more than a decade, but the threat of shoulder-fired surface-to-air missiles still makes travel into the airport, renamed Baghdad International Airport, dangerous. The coalition also rapidly reopened the civilian airports at Basra and Kirkuk.

The port facilities at Basra and nearby Umm Qasr were in disrepair after the Iran-Iraq War, the first Gulf War, and a decade of sanctions. Mines were an ever-present danger, so the ports were relatively insignificant early in the war. Coalition forces led by the British worked diligently to remove mines from the waterways and to repair the port infrastructure. The effort was essential both for Iraqi economic development and for potential military use that could take some of the pressure off the heavily used Kuwaiti port of Ash Shuibah.

The Impact of Geotechnology

The tools of the geographer are indispensable for planning and conducting military operations, whenever and wherever they occur. From the first use of maps for navigation and planning, to the utilization of aerial photographs and other remotely sensed imagery, to the exploitation of GIS and GPS, geotechnology has proved essential. Two of us—Mark Corson and Eugene Palka (2004)—argue that elements of the so-called Revolution in Military Affairs, including long-range precision strikes, dominant battlespace awareness, and space warfare, are all predicated on geographical technologies. Our case is bolstered by the coalition's experience in Operation Iraqi Freedom.

Maps have always been critical tools for soldiers. The challenge has been to produce accurate maps at appropriate scales that can be quickly distributed, en masse, to the troops. The U.S. and other NATO armies have the capability to update and rapidly produce topographic and specialized maps in mobile units close to the battlefield. During Operation Iraqi Freedom many units produced their own products from digital maps carried in computers. An Air Force program called "Falcon View" provides a digital map of all of Iraq that can change scales. The classified version enables users to zoom in to see satellite imagery of an area at high resolution. Users can customize their maps and print them out as needed. The integration

of digital maps into systems such as the Movement Tracking System coupled digital mapping with a GPS. The Movement Tracking System provides a digital map display with icons that show one's location and the location of other Movement Tracking System–equipped units. The system also facilitates text messaging via satellite and thus is an excellent long-range communications system.

Ever since kites and balloons with cameras were first used, remote sensing has been a tool for the soldier. Satellite imagery and data from other sensors is important in locating enemy forces. The new applications during Operation Iraqi Freedom include the use of unmanned aerial vehicles by tactical units to determine what is over the next hill or in the next village. Individual soldiers can now carry a small unmanned aerial vehicle that they can throw into the air and receive an image of, say, the next street. Small battlefield robots are also in use to detect and disarm roadside bombs, and even to reconnoiter the next room for enemies or booby traps during urban combat. And although the United States has always had superiority in night-vision devices, smaller and lighter versions of those devices are now issued to almost all combat soldiers, enabling them to operate effectively during darkness.

Military applications of GPS, which was developed by the U.S. Department of Defense, have evolved considerably. The system is still a critical navigation device for ascertaining location, but its integration with digital maps into systems such as the Movement Tracking System now depicts one's location on the map and enables one to make navigational calculations. This technology has proved to be important to logisticians for maintaining in-transit visibility of convoys and cargo. During Operation Iraqi Freedom the major evolution in the use of GPS was in targeting. Cruise missiles that formerly relied on terrain-following radar now use GPS to become extraordinarily accurate, and an inexpensive kit turns an old, unguided bomb into precision-guided Joint Direct Attack Munition.

The convergence of GIS using digital maps—to which is fed real-time information via remote sensing—and GPS-equipped units is creating a new generation of digital command and control systems. These systems enable U.S. and coalition commanders to know the locations of friendly and enemy units, their status, and their activities and to achieve dominant battlespace awareness. Systems such as Blue Force Tracker display the location of friendly and enemy units on a digital map by integrating information from the units and remote-sensing systems. Commanders can then use massed and/or precision firepower and maneuver their forces to avoid fratricide and collateral damage. Logisticians use the Battle Command Sustainment Support System to track and control the distribution of supplies to units. Systems such as these increase effectiveness dramatically and reduce waste.

These systems have their limitations, however, and they cannot solve all problems. Insurgent forces are often best detected by good, human intelligence; car bombs are best detected by alert soldiers, not satellites; and soldiers still must be able to use compasses and paper maps. Nevertheless, the evolution of these geographically based technologies is proving revolutionary, and their application may reduce civilian casualties and unintended damage.

Lessons Learned and Ongoing Challenges

The challenges introduced by Iraq's complex natural environment—blowing sand, dust, excessive heat, limited surface water, areas of soft soil that present trafficability problems for military track and wheeled vehicles—were anticipated by military planners. Consequently, military equipment, tactics, techniques, and procedures were modified appropriately. Even as Operation Iraqi Freedom continues, the prewar theoretical analysis of the natural environment differs little from the actual assessment on the ground.

Iraq's physical and human geography have had significant impacts on combat operations, as well as on efforts to secure, stabilize, and rebuild the country. Conversely, military operations have had a profound affect on the country and its people. Some of the impacts of Operation Iraqi Freedom were surely anticipated; other second- and third-order effects continue to challenge military planners, government officials, and nongovernmental organizations. A fundamental lesson learned is that any military geographical analysis represents a partially processed snapshot of the operating environment at a specific point in time. Wars provide unquestionable catalysts for change, both positive and negative, depending on one's perspective. As such, earlier military geographical analyses must be revisited and continually developed to take into account the devastating effects of warfare, the changing and enduring attitudes and perceptions of Iraqi citizens, the humanitarian efforts to help the country chart a new course, and the continuing political, economic, and cultural influences from outside sources.

Another lesson relates to the size of the initial U.S. force that was deployed in early 2003. Although the size of the invading force was more than sufficient to topple Saddam Hussein and his military, the initial force proved insufficient to secure the borders, stabilize the country, and restore order upon completion of combat operations. The continuing need to provide local security, rebuild infrastructure, and train Iraqi security forces spread coalition forces thinly throughout the country and enabled insurgents to remain active and continue to target unprotected areas. The spatial extent of the critical infrastructure alone, such as oil pipelines, would have required a substantially larger military force than was initially deployed. This highlights a major point of contention that surfaced between military and civilian leaders prior to the war. In the minds of Gen. Eric Shinseki, then chief of staff of the army, and some army planners, a large initial force of several hundred thousand was necessary, not to conduct decisive combat operations but to be positioned in Iraq to deal with the immediate aftermath of a successful military campaign and expeditiously begin the transition to stability-and-support operations. Several army officials thought that attaining tactical and operational success would be far easier than achieving strategic goals, which relied on successful stability-and-support operations upon completion of conventional combat operations. A few political leaders, however, believed that Shinseki's assessment was widely off the mark and opted to undertake Operation Iraqi Freedom with a considerably smaller ground force.

Politicians and military planners can also derive lessons that relate to the porosity of Iraq's borders. Despite a dictatorial regime that endured for decades, people, commodities, and ideas have moved back and forth across Iraq's borders, especially where similar culture groups, such as Kurds, straddle the boundaries. This scenario, which is not uncommon to geographers, opened the door for insurgents during and in the immediate aftermath of combat operations and continues to be a major concern. Aerial surveillance, a series of outposts linked by communications systems, and active patrols are proving to be effective means of remedying the situation.

Further lessons follow from attempts to understand the collective identity of Iraqis as a nation composed of a diverse array of ethnic and religious communities, culture groups that have had to endure decades of oppressive rule. During Hussein's tenure it was difficult to truly appreciate the hopes, fears, and aspirations of these oppressed communities in a political context that suppressed their identity in pursuit of national unity. Only now are we beginning to understand the centripetal and centrifugal forces within Iraq's plural society.

Finally, an extremely important lesson learned during the course of the "war on terrorism" in general and in Iraq in particular is that, now and in the foreseeable future, the U.S. military may be required to operate abroad concurrently within peacetime, stability-and-support operations, and wartime contexts. Operating abroad in any of the three contexts is challenging enough, but operating across the spectrum concurrently, versus sequentially, is unprecedented. In best-case scenarios, the transition between various stages of a campaign plan can be problematic, if not unpredictable. Despite the U.S. military's historical experience with transition challenges in other places, Iraq is unique, and contemporary security problems differ considerably from those encountered a few years ago in places like Bosnia and Kosovo. What has become clear is that combat operations, however decisive, do not guarantee the desired outcome of a democratic and peaceful Iraq and a stable Middle East. As experience has shown in countries such as Germany and Japan, and more recently in Bosnia and Kosovo, in the aftermath of war sustained peace can be achieved only through effective stability-and-support operations and long-term political and economic commitment.

Iraq currently stands at a crossroads. Time will tell whether the country becomes the beacon of democracy, stability, and prosperity envisioned by the Bush administration or a failed state that erupts into civil war, chaos, and anarchy, destabilizing the region and becoming a spawning ground for terrorist attacks against the United States and other nations around the globe.

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